CLAIMS

1. A method of depositing a ruthenium thin film by chemical vapor deposition, comprising processes of:

providing a substrate having an untreated dielectric layer;

providing an iodine-containing precursor gas;

generating a plasma discharge to create excited iodine species from said iodine-containing precursor gas;

exposing said dielectric layer to said excited iodine species to form a plasma-treated dielectric layer; and

then depositing a ruthenium thin film on said plasma-treated dielectric layer using a CVD technique.

2. A method as in claim 1 wherein:

said untreated dielectric layer does not comprise metal atoms.

3. A method as in claim 1 wherein:

said untreated dielectric layer comprises a silicon-containing dielectric compound.

4. A method as in claim 3 wherein:

said untreated dielectric layer comprises a material selected from the group consisting of SiO_2, BPSG, carbon-doped silicon oxide, CORAL^{TM}, nitrogen-doped silicon oxide, SiN, carbon-doped silicon nitride, SiC, and nitrogen-doped silicon carbide.

5. A method as in claim 1 wherein:

said untreated dielectric layer comprises a polymer-based carbon-hydrogen-oxygen-containing dielectric material having no silicon atoms.

6. A method as in claim 1 wherein:

said iodine-containing precursor gas comprises molecules selected from the group consisting of C_2H_5I, CH_3I CH_2I_2, $C_2H_4I_2$, and C_3H_7I.

7. A method as in claim 1 wherein:

said iodine-containing precursor gas comprises I_2.

8. A method as in claim 1 wherein said depositing a ruthenium thin film on said plasma-treated dielectric layer comprises:

using a MOCVD technique.

9. A method as in claim 1 wherein said depositing a ruthenium thin film on said plasma-treated dielectric layer comprises:

using an ALD technique.

10. A method as in claim 1 wherein said depositing a ruthenium thin film comprises depositing a thin film containing substantially ruthenium atoms.

11. A method as in claim 1 wherein said depositing a ruthenium thin film comprises depositing a thin film containing substantially ruthenium oxide.

12. A method as in claim 1 wherein said exposing said dielectric layer to said excited iodine species is conducted at low pressure.

13. A method as in claim 1 wherein said depositing a ruthenium thin film on said plasma-treated dielectric layer comprises:

depositing an ultra-thin ruthenium film having a thickness in a range of about from 1 nm to 20 nm.

14. A method of depositing a ruthenium thin film by chemical vapor deposition, comprising processes of:

providing a substrate having an untreated substrate surface;

providing a precursor of a surfactant species, said surfactant species selected from the group consisting of iodine, lead, tin, gallium, and indium;

generating a plasma discharge to create an excited surfactant species from said precursor;

exposing said untreated substrate surface to said excited surfactant species to form a plasma-treated substrate surface; and

then depositing a ruthenium thin film on said plasma-treated substrate surface using a CVD technique.

15. A method as in claim 14 wherein:

said untreated substrate surface comprises an untreated dielectric layer..

16. A method as in claim 15 wherein:

said untreated dielectric layer does not comprise metal atoms.

17. A method as in claim 15 wherein:

said untreated dielectric layer comprises a silicon-containing dielectric compound.

18. A method as in claim 17 wherein:

said untreated dielectric layer comprises a material selected from the group consisting of SiO_2, BPSG, carbon-doped silicon oxide, CORAL™, nitrogen-doped silicon oxide, SiN, carbon-doped silicon nitride, SiC, and nitrogen-doped silicon carbide.

19. A method as in claim 15 wherein:

said untreated dielectric layer comprises a polymer-based carbon-hydrogen-oxygen-containing dielectric material having no silicon atoms.

20. A method as in claim 14 wherein:

said untreated substrate surface comprises a metal nitride.

21. A method as in claim 14 wherein:

said surfactant species comprises iodine; and

said precursor comprises an iodine atom.

22. A method as in claim 21 wherein:

said precursor comprises molecules selected from the group consisting of I_2, C_2H_5I, CH_3I CH_2I_2, $C_2H_4I_2$, and C_3H_7I.

23. A method as in claim 14 wherein:

said surfactant species comprises lead; and

said precursor comprises a lead atom.

24. A method as in claim 23 wherein:

said precursor comprises molecules selected from the group consisting of Bis(2,2,6,6-tetramethyl-3,5-heptanedionato)lead (Pb(tmhd)$_2$, lead (II) hexafluoroacetylacetonate (Pb(hfac)$_2$), and Pb(C_6H_5)$_4$ (tetraphenyllead).

25. A method as in claim 14 wherein:

said surfactant species comprises tin; and

said precursor comprises a tin atom.

26. A method as in claim 25 wherein:

said precursor comprises molecules selected from the group

consisting of hexamethylditin, tetra-n-butyltin, tetramethyltin, tin (II)acetylacetonate ($Sn(acac)_2$), tin t-butoxide ($Sn(OC_4H_9)_4$).

27. A method as in claim 14 wherein:

said surfactant species comprises gallium; and

said precursor comprises a gallium atom.

28. A method as in claim 27 wherein:

said precursor comprises molecules selected from the group consisting of gallium (III) acetylacetonate ($Ga(acac)_3$) and triethylgallium ($Ga(C_2H_5)_3$).

29. method as in claim 14 wherein:

said surfactant species comprises indium; and

said precursor comprises an indium atom.

30. method as in claim 29 wherein:

said precursor comprises molecules selected from the group consisting of cyclopentadienylindium (C_5H_5In) and trimethylindium.

31. A method as in claim 14 wherein said depositing a ruthenium thin film on said plasma-treated substrate surface comprises:

using a MOCVD technique.

32. A method as in claim 31 wherein said depositing a ruthenium thin film on said plasma-treated substrate surface comprises:

using an ALD technique.

33. A method as in claim 14 wherein said depositing a ruthenium thin film comprises depositing a thin film containing substantially ruthenium atoms.

34. A method as in claim 14 wherein said depositing a ruthenium thin film comprises depositing a thin film containing substantially ruthenium oxide.

35. A method as in claim 14 wherein said exposing said dielectric layer to said excited iodine species is conducted at low pressure.

36. A method as in claim 14 wherein said depositing a ruthenium thin film on said plasma-treated dielectric layer comprises:

depositing an ultra-thin ruthenium film having a thickness in a range of about from 1 nm to 20 nm.

37. A method of forming a conductive metal-containing integrated circuit structure, comprising processes of:

providing a substrate having an untreated substrate surface;

providing a precursor of a surfactant species, said surfactant species selected from the group consisting of iodine, lead, tin, gallium, and indium;

generating a plasma discharge to create an excited surfactant species from said precursor;

exposing said untreated substrate surface to said excited surfactant species to form a plasma-treated substrate surface;

then depositing a ruthenium thin film on said plasma-treated substrate surface using a CVD technique; and

depositing a second metal layer on said ruthenium thin film.

38. A method as in claim 37 wherein said depositing a second metal layer on said ruthenium thin film comprises:

depositing a metal selected from the group consisting of copper, aluminum, titanium, and tungsten.

39. A method as in claim 37 wherein said depositing a second metal layer on said ruthenium thin film comprises:

electroplating copper on said ruthenium thin film.

40. A method as in claim 37 wherein said depositing a ruthenium thin film comprises:

depositing an ultra-thin ruthenium film having a thickness in a range of about from 1 nm to 20 nm.

41. A method of slowing the deposition of ruthenium on an integrated circuit substrate, comprising:

providing a substrate having an untreated substrate surface;

providing a precursor of a surfactant species, said surfactant species selected from the group consisting of iodine, lead, tin, gallium, and indium;

generating a plasma discharge to create an excited surfactant species from said precursor;

exposing said untreated substrate surface to said excited surfactant species to form a plasma-treated substrate surface; and

then depositing ruthenium on said plasma-treated substrate surface using a CVD technique.